# Turkey Flat, USA
# Site Effects Test Area

**Report 7**

## Strong-Motion Test: Prediction Criteria and Data Formats

**March 2005**

**CSMIP Report OSMS 05-1**
**California Geological Survey**
**Department of Conservation**

The Turkey Flat site effects test area is one of a series of international test areas endorsed by the International Association of Physics of the Earth's Interior and the International Association of Earthquake Engineers.

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## Turkey Flat, USA
## Site Effects Test Area

# Overview

**NEEDS** Recent earthquakes in Japan, Taiwan, and Turkey are reminders that local ground conditions can have a strong influence on where damage will occur in urbanized areas during an earthquake, and underscore the need to incorporate seismic shaking potential in land-use decisions. Although several different methods for making such assessments are currently in use, their accuracy and costs are not well known. Reliability and cost of methods must be known before they can be routinely used to provide a sound basis for safer land-use and construction practices.

**GOALS** The principal goals of the Turkey Flat Site Effects Test Area are to systematically compare and determine the reliability of contemporary methods used to estimate the effect of local geology on earthquake shaking, and to test the linearity of shallow stiff-soil site response.

**OBJECTIVES** Principal objectives are to collect high quality weak- and strong-motion data at several locations in the test area produced by local and regional earthquakes, quantify the site geology in terms of its geotechnical properties, and distribute the information to experts around the world.

**APPROACH** Using the acquired data, a series of "blind" predictions will be made by ground motion experts for test area locations where the response will be known, but not be available until all predictions have been received. Results of each prediction will be compared with one another and with actual observed ground motion.

**PRODUCTS** A series of reports describing each principal phase of the project will be available as the work progresses. An evaluation of all site response estimation methods will be prepared with recommendations as to suitability and cost of routine application for urban earthquake shaking hazard assessment.

## Acknowledgments

Recognition is due the following companies and corporations for their voluntary contributions which have made the Turkey Flat, USA Site Effects Test Area possible: LeRoy Crandall Associates (now MACTEC Environmental Consultants, Inc), Dames & Moore (now URS Corporation), Geomatrix Consultants, Harding Lawson Associates, Kajima Corporation, Lawrence Livermore National Laboratory, Pitcher Drilling Company, Qest Consultants, and Woodward-Clyde Consultants (now URS Corporation). We are especially indebted to OYO Corporation of Japan, who traveled great distances at great expense to contribute to the site characterization effort and share their technologies. We also wish to thank the California Department of Transportation for their assistance in field operations.

Most of all, we are grateful for the generosity and kindness of the land owners, Donald and Nila McCornack, and adjacent residents Melvin and Ruth Taylor, who persevered weeks of having the solitude of their setting disrupted. Their sincere interest in the future of mankind has made this experiment possible.

# Contents

# Foreword

At the 1985 General Assembly of the International Association of Seismology and Physics of the Earth's Interior (IASPEI), held jointly with the International Association of Earthquake Engineering (IAEE) in Tokyo, Japan, a resolution was passed forming a Joint Working Group on the Effects of Surface Geology on Seismic Motion (IASPEI/IAEE JWG-ESG). The purpose of the group is to coordinate the establishment of an international series of test areas designed to provide a database for comparing and testing contemporary methods, and develop new methods, to predict the effects of local geology on earthquake ground motion. Although methods for assessing site effects are being used in the design of critical facilities around the world, the reliability of these methods had not been rigorously tested. It is the goal of this program to fulfill this need. An international program provides a forum for experts around the world to exchange ideas, and significantly increases the prospects for acquiring the necessary data much sooner than would otherwise be possible.

Recognizing the importance of the effort to earthquake safety in California, in 1986, in anticipation of a Parkfield "characteristic" earthquake, the California Geological Survey (CGS) established a test area in a sedimentary valley at Turkey Flat, near Parkfield, California, where the California Strong Motion Instrumentation Program (CSMIP) installed a strong motion array. CGS partnered with the IASPEI/IAEE JWG-ESG as well as members of the geotechnical community to thoroughly characterize the geophysical properties of the site. The strong motion array consists of surface and downhole accelerometers, with surface instruments at the two valley edges, at one quarter of the valley width, and at the center of the small, shallow stiff-soil (25 m) sedimentary valley. The instruments at the valley center also include a downhole array, with instruments just beneath the rock interface and at mid-height in the sediments. At the XIX General Assembly of the International Union of Geodesy and Geophysics in Vancouver, British Columbia, 1987, a resolution was passed incorporating the experiment at Turkey Flat into the international program.

Eighteen years later, a M6.0 Parkfield earthquake occurred on September 28, 2004, which was well recorded throughout the test site array, providing the ground motion records necessary to conduct the long awaited "blind" strong-motion prediction test. In this prediction experiment, acceleration time histories recorded on bedrock near one valley edge is provided along with the geotechnical properties at all recording sites to interested participants. Participants are asked to make predictions of the ground motions at the five other recording locations (3 surface and 2 downhole), where, as part of a long-term plan, recordings are being withheld by CSMIP until the predictions have been received and officially logged. Details of the test area and the test procedure are distributed in an open invitation for all interested parties to participate in the blind test. A workshop at which predictions can be presented and comparisons made with the recorded motions is planned for Fall 2005.

**TURKEY FLAT, USA, SITE EFFECTS TEST AREA**
**STRONG-MOTION PREDICTION TEST**

# PART 1 - Prediction Criteria

## Introduction

Part 1 of this report describes the strong-motion site effects prediction test for the Turkey Flat, USA, Site Effects Test Area, and includes the prediction criteria determined by a committee of experts (see inside cover), and a test schedule. Input ground motion data and formats of input and requested output are discussed in Part 2 of this report. In addition to this report, participants should also have: a) Report 2, Site Characterization, and b) digital data files of strong ground motion recorded during the September 28, 2004 M6.0 Parkfield Earthquake at the Rock South (R1) and Rock Valley Center (D3) array sites at Turkey Flat. Together with this plan, these data are sufficient to estimate ground motions recorded at other array sites using participant-supplied methods.

As described below, several ground-motion estimates are requested to be made given these data. They will be made for sites where the actual ground motion has been recorded, but will be kept confidential until all prediction estimates have been received. Consequently, the tests are "blind predictions" whereby methods of estimating the effects of local site geology will be tested without prior knowledge of the actual site effects. When all predictions have been received, participant results will be compared with one another and with actual recorded ground motions at each site.

## Strong-Motion Test

### Instrument Array

A schematic cross-section of the Turkey Flat array is shown in figure 1. The array is composed of seven recording sites indicated by solid circles having accompanying alphanumeric identification codes beginning with a letter corresponding to R (rock), V (valley), and D (downhole). All predictions that are requested to be made will reference sensor locations by these codes. Each site records three orthogonal components of ground acceleration the records for which are described in Part 2 of this report. Site names have been given to each surface instrument location: Rock South (R1), Valley Center (V1), Valley North (V2), and Rock North (R2).

## Turkey Flat Strong-Motion Array Configuration

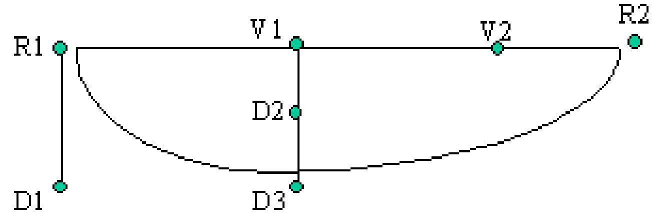


**Figure 1. Cross-section schematic**

### Table 1. Array Sensor Locations and Coordinates

| Location Code | Lat | Long | Depth (m) | Station Number | SMIP Station Name |
|---|---|---|---|---|---|
| R1 | 35.878 | -120.358 | 0 | 36529 | Parkfield - Turkey Flat #1 |
| D1 | 35.878 | -120.358 | 24 | | |
| | | | | | |
| V1 | 35.882 | -120.350 | 0 | 36520 | Parkfield - Turkey Flat #2 |
| D2 | 35.882 | -120.350 | 10 | | |
| D3 | 35.882 | -120.350 | 24 | | |
| | | | | | |
| V2 | 35.886 | -120.350 | 0 | 36519 | Parkfield - Turkey Flat #3 |
| | | | | | |
| R2 | 35.892 | -120.352 | 0 | 36518 | Parkfield - Turkey Flat #4 |

Instruments at each location are oriented West, Up, North.

## Ground Motion Predictions

Figure 2 shows the REQUIRED and OPTIONAL ground motion predictions that are to be made in three general forms: 1) Fourier Amplitude Spectral Ratios, 2) Acceleration Time Histories, and 3) 5% Damped Pseudovelocity Response Spectra. We also request that Peak Values of Acceleration, Velocity, and Displacement be provided. To participate fully in the experiment one should compute, for each horizontal component, all of the items for each form of prediction listed under the heading "REQUIRED" using a participant-developed Preferred Geotechnical Model and instrument corrected acceleration time histories for the specified event. Participants are requested to develop a Preferred Geotechnical Model from the basic data contained in Report 2 and submit a complete set of predictions based on their preferred model. The requested predictions consist of 42 plots in all.

A Standard Geotechnical Model is provided in order to facilitate comparison of ground motion estimation methods, since each prediction will use the same geotechnical model and same input motions. This will also permit comparison with results of the weak-motion test conducted in 1989-90. Although "Optional", we encourage participants to provide predictions based on the Standard Geotechnical Model as well. This would result in an additional 42 plots, yielding a total of 84 plots.

## Submittals

Participants are requested to submit all results as digital data files on computer readable media (e.g. CD-ROM), or alternatively downloadable from an Internet file transfer protocol (ftp) server. Standard formats for the digital data are described in Part 2 of this report.

## Terms and Conditions

Participation in the Turkey Flat test is voluntary, but registration implies a commitment to carry out predictions of ground motions across the array according to the format, terms and conditions of the test. Each participant must provide contact information, and identify the method that will be used to make the required predictions. Participants are encouraged to also perform "optional" predictions, as the results will help to further validate the methods employed. ***All information provided through the online registration form will be kept confidential, and predictions will remain anonymous when comparing the results***. Additional requirements include the following:

1) The predictions must be made using a "preferred" geotechnical model of the site that each participant will construct from the basic geotechnical data provided.

## Strong-Motion Prediction Test
## (Volunteer Program)

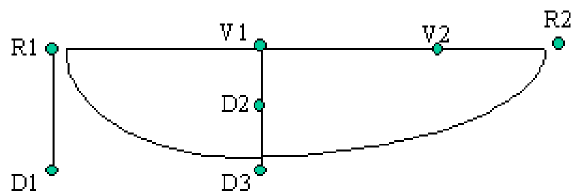


**Figure 2. Vertical profile of Turkey Flat Strong-Motion Array**

1."REQUIRED" Strong-Motion Test Predictions (both horizontal components):

- **Fourier Amplitude Spectral Ratios:**

  **1) Xi/R1 given R1 (where Xi means D1, D2, D3, V1, V2, R2)**
  **2) V1/D3, D2/D3 given D3**

- **Acceleration Time Histories:**

  **1) V1, D2, D3 given R1**
  **2) V1, D2 given D3**

- **Pseudovelocity Response Spectra (5% damped) & peak values displacement, velocity, acceleration**

  **1) $X_i$ given R1 (where $X_i$ means D1, D2, D3, V1, V2, R2)**
  **2) V1, D2 given D3**

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2."OPTIONAL" Strong-Motion Predictions:

**1) Full set of above predictions using the “standard” geotechnical model.**
**2) Acceleration time histories for V2, R2, given R1 for “preferred” geotechnical model.**
**3) Acceleration time histories for V2, R2, given R1 for “standard” geotechnical model.**
**4) Compute each prediction for vertical component of motion.**

3) Prediction results must include estimates of uncertainty (e.g. standard error).
4) All predictions must be made for both horizontal components.
5) Final results will be submitted in the digital format that is prescribed in Part 2 of this report.
6) Final submissions should include a brief report that describes the ground motion model and the "preferred" geotechnical model of the site.
7) Participants are encouraged to complete all predictions; however, predictions for either Phase I (based on input record from R1) or Phase II (based on input ground motion record from D3) will be accepted.

# Schedule

Table 2 outlines the schedule and procedure to be followed for the Weak-Motion Tests. All data necessary for predicting the response of the Turkey Flat Strong-Motion Array are available on the project website (http://www.quake.ca.gov/turkey flat.htm). The test is conducted in two phases: Phase I (R1-based predictions) and Phase II (D3-based predictions). Predictions based on R1 input motions are due August 15, 2005, and must be postmarked no later than this date to be considered a valid "blind" prediction.

Table 2. Project Schedule

| PHASE | ACTIVITY | DATE |
|---|---|---|
| I | Announcement of Test | 12/2005 |
| | R1 Records Distributed | 3/15/2005 |
| | R1 Predictions Due | 8/15/2005 |
| II | D3 Records Distributed | 8/22/2005 |
| | D3 Predictions Due | 10/17/2005 |
| | Fall Workshop | November |

On August 22, 2005, after all predictions based on the records at site R1 have been received, records at site D3 will be distributed. At this time, participants will be able to compare their predicted motions at site D3 with actual recorded motions. Predictions based on D3 input motions are due October 17, 2005, and must be postmarked no later than this date to be considered a valid "blind" prediction.

On October 31, 2005, after all predictions based on the records at site D3 have been received, actual recorded ground motions at all array sites will be distributed to participants for analysis of observed and predicted ground motions. A workshop will then be scheduled in November 2005. Participants are encouraged to subsequently publish their work in refereed technical journals.

# TURKEY FLAT, USA, SITE EFFECTS TEST AREA
# STRONG-MOTION PREDICTION TEST

## PART 2 – Data Formats

## Introduction

Part 2 of this report describes the input rock motion and prediction data file formats for the Strong-Motion Test, and is divided into four sections. The first section presents the required rock input record (R1) and data format. Sections 2 and 3 describe the standard prediction file and plot formats respectively. Detailed information on data formats is provided in Appendices A and B. An example of peak value table format is shown in section 4. Having a standard format for prediction results greatly facilitates comparisons during analysis. Because plots of the input rock motions are provided in this part of the report, it is convenient to use them as examples of the format required from all participants for all output.

## Input Motions and Data Formats

Strong-motion records from the September 28, 2004 M6.0 Parkfield Earthquake recorded at Rock South (R1) and Rock Valley Center (D3)sites at Turkey Flat are provided as the bedrock input records for predicting strong-motion response across Turkey Flat array (figure 2). These records are made available in two phases according to the schedule described in Part 1 of this report. Details of the source event are on the Parkfield Earthquake website (http://www.quake.ca.gov/ - Parkfield_2004), and the location coordinates are provided in the input file headers. The input ground motion data files are available through the California Integrated Seismic Network (CISN) Data Center. All three components of bedrock motion are provided. The units of strong-motion acceleration are cm/sec/sec. Details about recording equipment, data processing, and instrument corrections are available.

### Standard Input File Format

Input ground motions and predicted ground motions are in three different forms as discussed in Part 1: 1) Fourier amplitude spectral ratio, 2) time history, and 3) pseudovelocity response spectrum. Each form has a corresponding data file and plot format. Input ground motion data are distributed in the standard CSMIP data format, which is described in a separate report available on the Turkey Flat project website (http://www.quake.ca.gov/cisn-edc/Reports/DMGformat85.pdf). Participants are required to return paper plots of results similar to each of the three standard CSMIP

Volume 2 plot formats to allow for visual inspection. Participants are also requested to return prediction results in computer readable media (e.g. CD-ROM) in three simplified data file formats described below to facilitate statistical comparisons and help summarize experiment results.

## Prediction File Formats

The three standard computer-readable data-file formats for submitting prediction results are simplified, and generally conform to California Strong Motion Instrumentation Program (CSMIP) standards (Shakal and Huang, 1985). They are described as follows.

### *Time Histories*

Time Histories are distributed in standard CSMIP Volume 2 format (Shakal and Huang , 1985) http://www.quake.ca.gov/cisn-edc/Reports/DMGformat85.pdf . Although velocity and displacement will be computed in the course of determining peak values, only acceleration time history data files are requested to be provided.

### *Response Spectra*

Response spectra will be in an abbreviated CSMIP Volume 3 format, hereafter referred to as the Response Spectra (RS) format. **Appendix A** contains the RS format standard which has been modified from Shakal and Huang for this experiment by retaining only the header array, sample periods array, and the 5% damped psuedovelocity response spectrum array. Response spectral values will be computed at the standard periods listed in Appendix A. Real-Header elements 66, 68, and 70 should contain peak acceleration, peak velocity, and peak displacement respectively, even though the time history files are not requested for all sites. An example for R1 is also included in Appendix A.

### *Fourier Amplitude Spectral Ratio*

There is no CSMIP standard for this output form, so a standard for this experiment has been devised that conforms with the Volume 2 and 3 standards. **Appendix B** contains a description of the chosen Fourier amplitude spectral ratio (FSR) standard plus an example. Fourier spectra should be smoothed before calculating ratios. Smoothing should be equivalent to a 1 Hz running-mean window passed twice over the individual spectra. Data files received by participants will conform to these three standards with the exception of: 1) the inclusion of the word "OBSERVED" in columns 45-52 of Text Header 6 of Volume 2 files (hence in columns 45-52 of Text Header 7 of RS and FSR files), and 2) the unit of length for weak-motion time history and response spectrum files will be centimeters.

Data files returned by participants shall conform to these three standards and include: 1) the words "STANDARD GEOTECHNICAL MODEL" or "PREFERRED GEOTECHNICAL MODEL" in columns 51-80 of Text Header 3 of Volume 2 files (predicted time histories) and Text Header 4 of RS and FSR files (predicted response spectra and spectral ratios), and 2) the words "PREDICTED BY" and your name or identification number in columns 45-80 of Volume 2 Text Header 6 (Text Header 7 for RS and FSR files) (see samples in Appendices A and B).

## Prediction Plot Formats

To verify the contents of data files and facilitate comparison with observations, participants should provide results on three standard paper plots. Both data sent to participants and predictions received from participants should conform to these plot standards (please include your name on all plots). The following are guidelines for all plots.

### *Time History*

Time History Plots are scaled so that: 1) the horizontal axis ranges from 12 to 20 seconds with second marks having 10 mm spacing, and 2) the vertical axis is in cm auto-scaled so that all components are scaled to the largest maximum peak-to-peak amplitude equal to 36 mm (the vertical axis length will be 40 mm which leaves a 2 mm space between the largest component extremum and its corresponding axis limit). All three components are plotted on a single page (vertical optional). An example for R1 is shown in figure 3.

### *Response Spectrum*

Response Spectrum Plot scaling is 30 mm/decade logarithmic for both horizontal and vertical axes. The vertical scale is pseudovelocity amplitude in cm/sec, ranging over three decades. The horizontal axis is period ranging from .03 to 30 seconds (total horizontal axis length is 90 mm). Both components are plotted on a single page. An example for R1 is shown in figure 4 (tri-partite plot optional).

### *Fourier Amplitude Spectral Ratio*

Fourier Amplitude Spectral Ratio Plots are scaled: 1) so that the linear horizontal frequency scale ranges from 0 to 20 Hz with 10 mm spacing between 1 Hz divisions, and 2) the linear vertical axis is in dimensionless units auto-scaled so all components are scaled to the largest maximum peak-to-peak amplitude equal to 76 mm (the vertical axis length will be 80 mm which leaves a 2 mm space between the largest component extremum and its corresponding axis limit). Both components are plotted on a single page. An example for R1 is shown in figure 5.

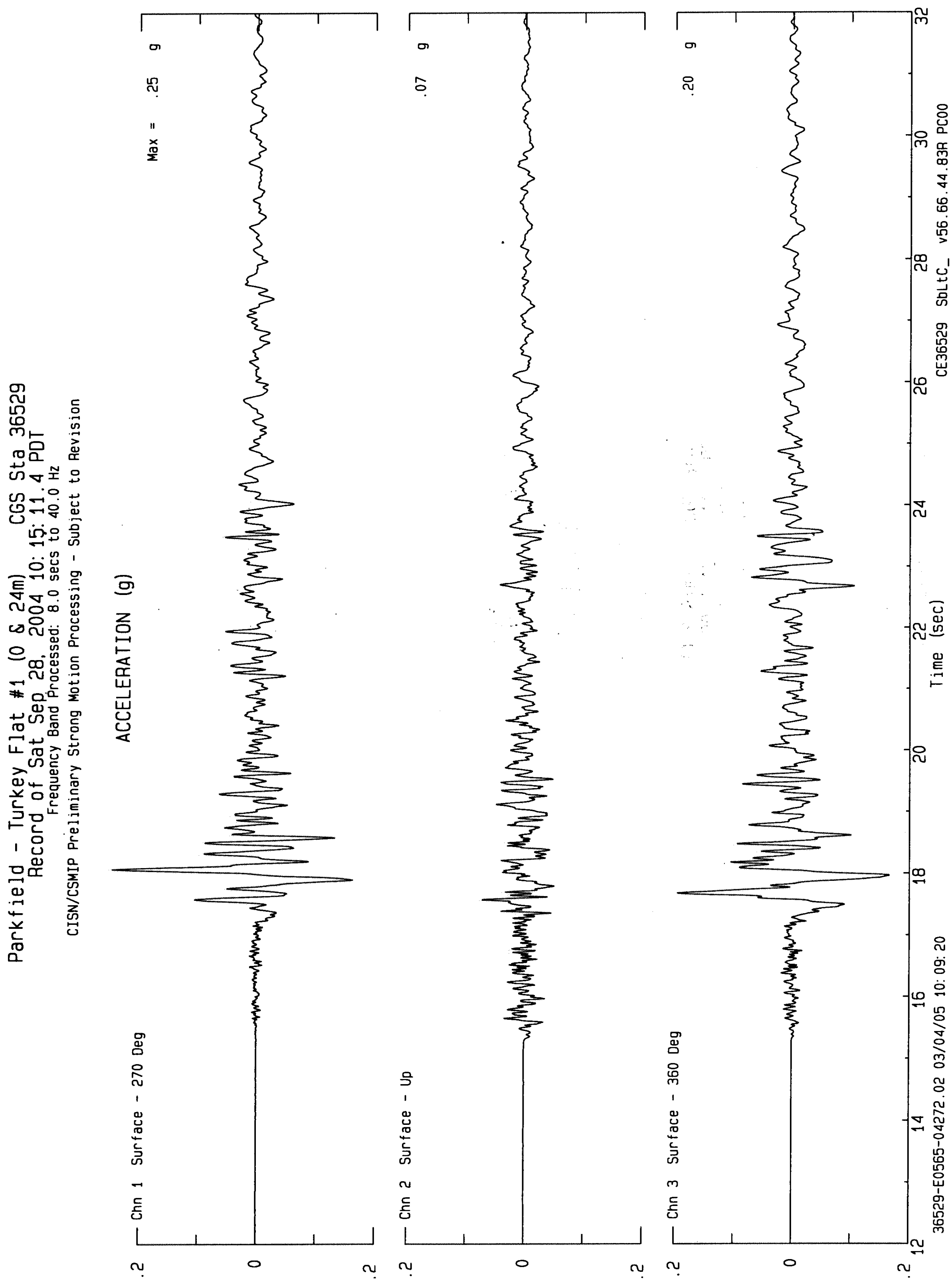


Figure 3. Standard Time History Accelerogram Plot (note: vertical axis units are cm/sec/sec for strong-motion test).

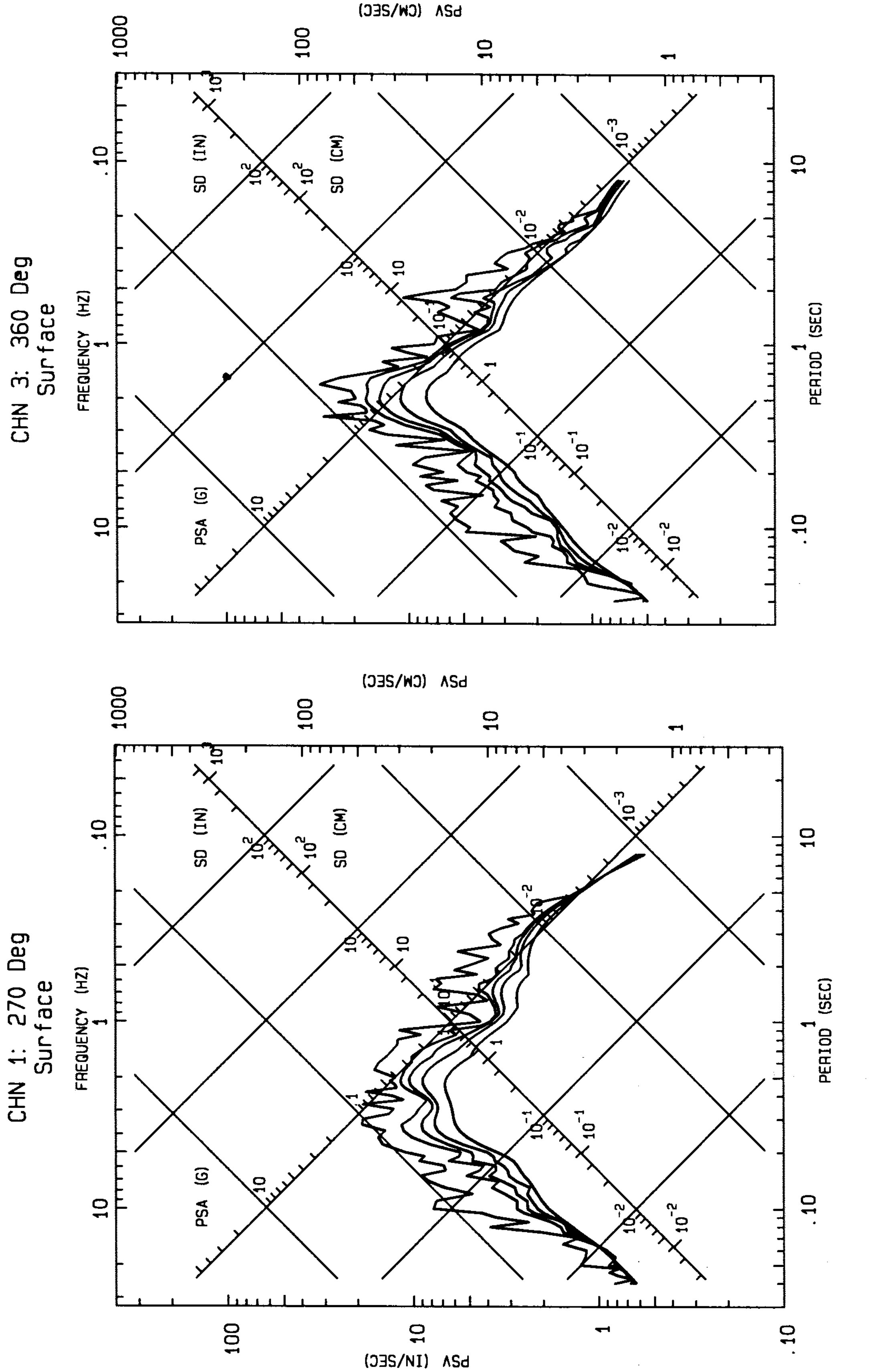


Figure 4. Standard Pseudovelocity Response Spectra Plot (vertical axis units are cm/sec for strong-motion test).

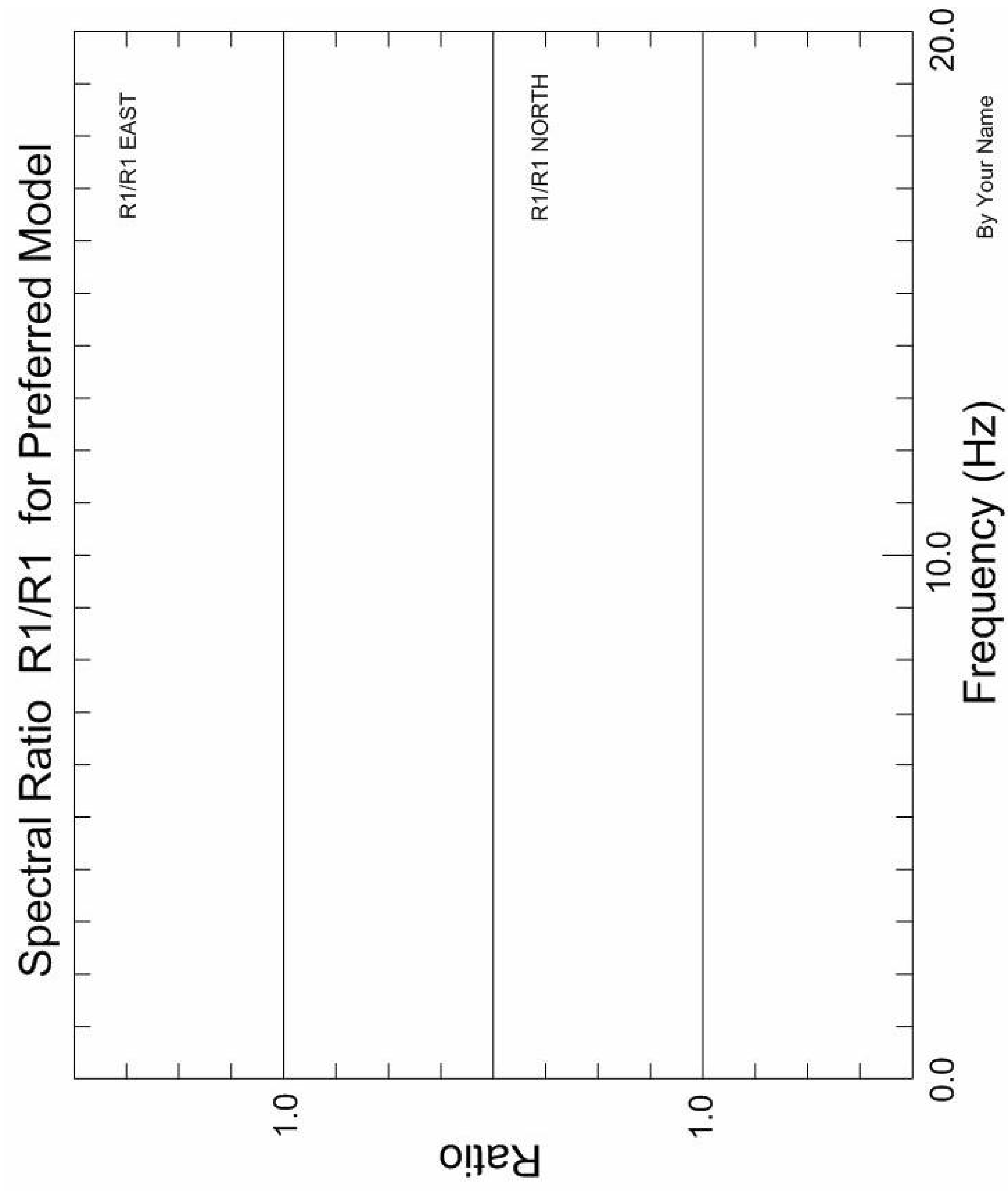


Figure 5. Standard Fourier Amplitude Spectral Ratio Plot (example is input record R1 to itself – unity).

## Peak Acceleration, Velocity, and Displacement

Peak values of ground motion parameters are to be provided for the sensor locations as indicated in figure 1 and Table 1 of the ground motion prediction plan (see Part 1). The values are to be provided as tables either by copying and filling in the tables shown in Tables 3 and 4, or preparing tables of similar format. Peak values of ground motion parameters are also requested to be included in the RS files (see Response Spectrum file format).

Table 3. Peak Ground Motions Table for Strong-Motion Record R1

| GIVEN INPUT ROCK MOTIONS AT R1 | | | | |
|---|---|---|---|---|
| Sensor Location | | Acceleration (cm/sec/sec) | Velocity (cm/sec) | Displacement (cm) |
| V1 | N | | | |
| | E | | | |
| | V | optional | optional | optional |
| D2 | N | | | |
| | E | | | |
| | V | optional | optional | optional |
| D3 | N | | | |
| | E | | | |
| | V | optional | optional | optional |
| V2 | N | optional | optional | optional |
| | E | optional | optional | optional |
| | V | optional | optional | optional |
| R2 | N | optional | optional | optional |
| | E | optional | optional | optional |
| | V | optional | optional | optional |
| D1 | N | optional | optional | optional |
| | E | optional | optional | optional |
| | V | optional | optional | optional |

Table 4. Peak Ground Motions Table for Strong-Motion Record D3.

| GIVEN INPUT ROCK MOTIONS AT D3 | | | | |
|---|---|---|---|---|
| Sensor Location | | Acceleration (cm/sec/sec) | Velocity (cm/sec) | Displacement (cm) |
| V1 | N | | | |
| | E | | | |
| | V | optional | optional | optional |
| D2 | N | | | |
| | E | | | |
| | V | optional | optional | optional |

# References


Shakal, A.F., and Huang, M.J., 1985, Standard tape format for CSMIP strong-motion data tapes: California Division of Mines and Geology, California Strong Motion Instrumentation Program, Report OSMS 85-03.

# Appendix A

## Response Spectra Format Standards for the Ground-motion Prediction Phase of the Turkey Flat, USA, Site Effects Test Area Experiment.

**(modified from "Standard Tape Format for CSMIP Strong-motion Data Tapes"**
**by A.F. Shakal and M.J. Huang, 1985)**

## RESPONSE SPECTRA FILE FORMAT

A Response Spectra (RS) file contains RS information for a specific station. For each channel included in the file, the file has three headers, spectral parameters, and values of one response spectra at each of up to 100 periods. Specifically, the elements of an RS file, for each channel, are:

1. Text header, alphanumeric
2. Integer header
3. Real-value header
4. Damping value for the response spectrum
5. Periods at which the spectrum is computed
6. Pseudovelocity response spectrum values
7. End-of-data flag (/&)

These seven elements are then repeated for the next channel in the file. The text header is very similar to the Volume 2 text header. The integer header is the same as that of the Volume 2 file except for three elements. The real-value header is identical to that of the Volume 2 file.

The headers and file contents are described on the following pages. These descriptions are followed by an actual listing, in summary form, of a RS file.

S -

RS TEXT HEADER (TXTHDR)

The text header occupies 30 lines of alphanumeric text, which are lines 1-30 of the information for a given channel. This text header is nearly identical to the text header for the corresponding Volume 2 file.

| Line | Column | Description |
|---|---|---|
| 1 | 1-80 | RS title line |
| 2-16 | - | Same as lines 1-15 of Volume 2 text header, except line 4, col. 51-80 indicates geotechnical model used and line 7, col. 45-80 indicates whether data is observed, or predicted and by whom. |
| 17 | 18-51 | Same as line 16 of Volume 2 text header with only characters in col. 18-51 copied over. |
| 18-22 | - | Blank |
| 23-26 | - | Same as lines 22-25 of Volume 2 text header |
| 27-28 | - | Same as lines 25 and 26 |
| 29-30 | - | Units of spectra |

RS INTEGER HEADER (IHDR)

The integer-value header is a 100-element array, written in lines 31-37 of the header, in format 16I5. It is identical to the integer array for the Volume 2 file, except for elements 67-69.

| Line | Array Element | Description |
|---|---|---|
| 31-37 | 1-100 | Same as elements 1-100 of Volume 2 integer header, except element 67 which is no. of letters for plotting station name (IHDR(60)+1), element 68 which is no. of periods for which spectral values are computed, and element 69 which is no. of damping values for which response spectral values are computed (always 1) |

RS REAL-VALUE HEADER (RHDR)

The real-value header is a 100-element floating-point array, written in lines 38-50 of the header, in format 8F10.3. The header is identical to the corresponding header for a Volume 2 file.

| Line | Array Element | Description |
|---|---|---|
| 38-50 | 1-100 | Same as elements 1-100 of Volume 2 real-value header; Peak acceleration, velocity, and dis- placement are required in elements 66, 68, & 70 respectively, even if a Volume 2 file is not provided. |

RESPONSE SPECTRAL PARAMETERS

| Line | Parameter | Description |
|---|---|---|
| 51 | DMPNG | Damping value used in response spectrum |
| 52-64 | PD(I), I=1,100 | Periods at which the spectrum is com puted (standard values are: .04, .042, .044, .046, .048, .05, .055, .06, .065, .07, .075, .08, .085, .09, .095, .10, .11, .12, .13, .14, .15, .16, .17, .18, .19, .20, .22, .24, .26, .28, .30, .32, .34, .36, .38, .40, .42, .44, .46, .48, .50, .55, .60, .65, .70, .75, .80, .85, .90, .95, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0, 3.2, 3.4, 3.6, 3.8, 4.0, 4.2, 4.4, 4.6, 4.8, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10., 11., 12., - 13., 14., and 15. seconds. These are 91 periods; the remaining 9 array elements are set to 0.0) |
| 65 | - - | Label and damping for response spectral values |
| 66-78 | PV(I), I=1,100 | Pseudovelocity response spectral values at periods PD(I). |

**Sample Response Spectra File Listing for Turkey Flat experiment:**

```
RESPONSE AND FOURIER AMPLITUDE SPECTRA (82 PERIODS,  .04 -  8.0 SEC)    FOR
CORRECTED ACCELEROGRAM   36529-E0565-04272.02       CHAN  1: 270 DEG     FROM
UNCORRECTED ACCELEROGRAM DATA             PROCESSED: 03/04/05, CDMG  E0565E02
RECORD OF SAT SEP 28, 2004 10:15:11.4 PDT            (AVOL1 V6.7, 1/05 CSMIP)
CSMIP PRELIMINARY PROCESSING            (ORIGIN:  TO BE DETERMINED)
36529-E0565-04272.02                 START TIME:  9/28/04, 17:15:11.4 UTC (WWVB)
STATION NO. 36529   35.878N, 120.358W     SSA-1  S/N  565  (3 CHNS OF  6 AT STA)
PARKFIELD - TURKEY FLAT #1 (0 & 24M)      CGS
CHAN  1: 270 DEG                    LOCATION: SURFACE
RECORD OF SAT SEP 28, 2004 10:15:11.4 PDT    SAT SEP 28, 2004 10:15:11.4 PDT
HYPOCENTER:  TO BE DETERMINED.               ML:  TO BE DETERMINED.
INSTR PERIOD =  .0222 SEC,  DAMPING =  .700,  SENSITIVITY = 1.25  V/G  (NOMINAL)
                        RECORD LENGTH = 81.920 SEC.
                                     UNCOR MAX  =   .245 G , AT  18.075 SEC.
RMS ACCEL OF (UNCOR) RECORD  =        .   STA. METADATA EFFECTIVE DATE: 01/01/04
ACCELEROGRAM BANDPASS FILTERED WITH 3 DB PTS AT   .13 AND 40.00 CYC/SEC
                 INSTRUMENT- AND BASELINE-CORRECTED




RECORD OF SAT SEP 28, 2004 10:15:11.4 PDT    SAT SEP 28, 2004 10:15:11.4 PDT

36529-E0565-04272.02      PARKFIELD - TURKEY FLAT #1 (0 & 24M)    CHAN  1: 270 D
EG
36529-E0565-04272.02      PARKFIELD - TURKEY FLAT #1 (0 & 24M)    CHAN  1: 270 D
EG
UNITS FOR SPECTRA ARE INCHES AND SEC, EXCEPT SA IS IN FRACTION OF G.

    1  100    1    3    6  200    1    3    2   12    5  565    036529    4    0
   17   15   11  350  262    9   28 2004   10    1  27016384   41   36   76   -1
16384    1   50    3    0    1    2   64    1   17   15    8  260    9   28 2004
    2    2    0    0 8192    2   21    0   12    4   76   36    0    0    0 8192
    3 8192   37   82    5    3    5    0    0    0    6    0    0    3    0    2
    2    2    4    1   65   99    1   32   32    0    0    1    0    0   13  130
    2    1    0    0
      .022      .700    81.920      .012      .000  1250.000      .245    18.075
    45.000  1220.703   976.563      .000     5.000      .000      .000      .000
     2.500    -.091     2.500  -999.000    15.360    30.000      .000      .011
     -.096    -.107     2.000    15.000    35.878  -120.358      .185      .504
     2.729    -.141     -.074   491.000      .000      .000      .000      .000
    23.852    -9.404    7.000      .000      .000      .000      .000      .000
     5.700     6.700    4.400   980.665      .010    81.920     7.162      .000
      .000    40.000     .000    81.920      .010      .125      .000      .000
    18.070   240.594   17.990   -14.585    18.100    -1.391     .002      .125
    40.000      .010     .010      .004     6.510      .275     .000      .000
      .559      .260     .430      .479      .062      .015     .000      .000
      .000      .000     .000      .000      .000      .000     .000      .000
      .000      .000     .000      .000
      .000      .020     .050      .100      .200
      .040      .042     .044      .046      .048      .050     .055      .060
      .065      .070     .075      .080      .085      .090     .095      .100
           .....(Remainder of 100 element period array) .....
Damping =  .05. Data of Pssv :
  .653E+00  .665E+00  .696E+00  .720E+00  .764E+00  .825E+00  .832E+00  .904E+00
           ....(Remainder of 100 element pseudovelocity array) .....

/&    <——- ....(End of data for this channel)

           ....(Header, etc for next channel)
```

# Appendix B

## Fourier Spectral Ratio Format Standards
## for the Ground-motion Prediction Phase of the Turkey Flat, USA, Site Effects Test Area Experiment.

## FSR FILE FORMAT

A Fourier Spectral Ratio (FSR) file contains FSR information for a specific station with respect to a specified reference station. For each channel included in the file, the file has three headers and Fourier spectral ratio parameters either equally or unequally spaced in the frequency domain. Specifically, the elements of an FSR file, for each channel, are:

1. Text header, alphanumeric

2. Integer header

3. Real-value header

4. Frequency data-start line (unevenly-spaced only)

5. Frequency sample points (unevenly-spaced only)

6. Fourier spectral ratio data-start line

7. Fourier spectral ratio values

8. End-of-data flag (/&)

These eight elements are then repeated for the next channel in the file. The text header is very similar to the Volume 2 text header. The integer header is the same as that of the Volume 2 file except for one element indicating an evenly or unevenly spaced file. The real-value header is identical to that of the Volume 2 file. The headers and file contents are described on the following pages. These descriptions are followed by an actual listing, in summary form, of a FSR file.

FSR -

## FSR TEXT HEADER (TXTHDR)

The text header occupies 25 lines of alphanumeric text, which are lines 1-25 of the information for a given channel. This text header is nearly identical to the text header for the corresponding Volume 2 file.

| Line | Column | Description |
|---|---|---|
| 1 | 1-80 | FSR title line giving reference station in col. 51-75 |
| 2-16 | - | Same as lines 1-15 of Volume 2 text header, except line 4, col. 51-80 indicates geotechnical model used and line 7, col. 45-80 indicates whether data is observed, or predicted and by whom. |
| 17 | 1-80 | FFT window line with start and end times from front of trace given in col. 38-44 & 64-70. |
| 18-9 | 1-80 | Smoothing lines with # times smoothed in line 18, col. 53 and filter width in line 19, col. 8-15. For evenly spaced file, filter width is in # points, and for unevenly spaced file, filter width is in Hz (see examples). |
| 20 | 1-80 | FSR data window line with start and end frequencies of FSR data given in col. 31-36 & 53-59. |
| 21 | 1-80 | FSR sampling line with # of points in col. 1-5 and, for evenly sampled data only, interval size in col. 68-75 (Hz). |
| 22-5 | 1-80 | Same as lines 22-25 of Volume 2 text header |

## FSR INTEGER HEADER (IHDR)

The integer-value header is a 100-element array, written in lines 26-32 of the header, in format 16I5. It is identical to the integer array for the Volume 2 file, except for element 40.

| Line | Array Element | Description |
|---|---|---|
| 26-32 | 1-100 | Same as elements 1-100 of Volume 2 integer header, except element 40 which is 1 for evenly spaced and 2 for unevenly spaced data. |

SR -

FSR REAL-VALUE HEADER (RHDR)

The real-value header is a 100-element floating-point array, written in lines 33-45 of the header, in format 8F10.3. The header is identical to the corresponding header for a Volume 2 file.

| Line | Array Element | Description |
|---|---|---|
| 33-45 | 1-100 | Same as elements 1-100 of Volume 2 real-value header. |

**Sample Even FSR File Listing for Turkey Flat experiment:**

```
RESPONSE AND FOURIER AMPLITUDE SPECTRA (82 PERIODS,  .04 -  8.0 SEC)   FOR
CORRECTED ACCELEROGRAM   36529-E0565-04272.02       CHAN  1: 270 DEG     FROM
UNCORRECTED ACCELEROGRAM DATA             PROCESSED: 03/04/05, CDMG  E0565E02
RECORD OF SAT SEP 28, 2004 10:15:11.4 PDT            (AVOL1 V6.7, 1/05 CSMIP)
CSMIP PRELIMINARY PROCESSING            (ORIGIN:  TO BE DETERMINED)
36529-E0565-04272.02                 START TIME:  9/28/04, 17:15:11.4 UTC (WWVB)
STATION NO. 36529   35.878N, 120.358W     SSA-1  S/N  565  (3 CHNS OF  6 AT STA)
PARKFIELD - TURKEY FLAT #1 (0 & 24M)      CGS
CHAN  1: 270 DEG                    LOCATION: SURFACE
RECORD OF SAT SEP 28, 2004 10:15:11.4 PDT    SAT SEP 28, 2004 10:15:11.4 PDT
HYPOCENTER:  TO BE DETERMINED.               ML:  TO BE DETERMINED.
INSTR PERIOD =  .0222 SEC,  DAMPING =  .700,  SENSITIVITY = 1.25  V/G  (NOMINAL)
                        RECORD LENGTH = 81.920 SEC.
                                     UNCOR MAX  =   .245 G , AT  18.075 SEC.
RMS ACCEL OF (UNCOR) RECORD  =        .   STA. METADATA EFFECTIVE DATE: 01/01/04
ACCELEROGRAM BANDPASS FILTERED WITH 3 DB PTS AT   .13 AND 20.00 CYC/SEC
FFT COMPUTED FROM WINDOW STARTING AT  6.741  SEC AND ENDING AT  14.741 SEC.
AMPLITUDE SPECTRA OF STATION AND REFERENCE SMOOTHED 2 TIMES
WITH An 11 POINT RUNNING MEAN FILTER BEFORE FORMING SPECTRAL RATIO.
SPECTRAL RATIO DATA BEGINS AT  .125 HZ AND ENDS AT 20.000  HZ.
  203 POINTS OF SPECTRAL RATIO DATA AT EQUALLY-SPACED INTERVALS OF 0.09766  HZ.
PARKFIELD EARTHQUAKE

STRONG-MOTION EVENT, TURKEY FLAT ARRAY, ROCK SOUTH (SURFACE)  CHAN  1: 90 DEG

    1    1    1    3    3    0    1    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0   90 2873   40   40   25    0
    0    0    0    0    0    0    0    1    0    0    0    0    0    0    0    0
    0    0 2873 2873 2873    0    0    0    0    0   25   80    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
     0.500     0.600    28.720     0.000     0.000     0.000     0.000     0.000
     2.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000    12.566     0.000
     0.000     0.000     0.000     0.000     0.010     0.000     0.000     0.000
     7.840  -415.426     7.870     9.047    10.770    -0.353     0.007     0.000
     0.000     0.000    -0.002     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000
  203 POINTS OF SPECTRAL RATIO DATA EQUALLY SPACED AT 0.097 HZ (UNITS: RATIO):
     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000
     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000
     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000
     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000
          ...(Remainder of acceleration data) ...

/& <----- ...(End of data for this channel)...

          ...(Header, etc for next channel)...
```

**Sample Uneven FSR File Listing for Turkey Flat experiment:**

```
RESPONSE AND FOURIER AMPLITUDE SPECTRA (82 PERIODS,  .04 -  8.0 SEC)   FOR
CORRECTED ACCELEROGRAM   36529-E0565-04272.02       CHAN  1: 270 DEG     FROM
UNCORRECTED ACCELEROGRAM DATA             PROCESSED: 03/04/05, CDMG  E0565E02
RECORD OF SAT SEP 28, 2004 10:15:11.4 PDT             (AVOL1 V6.7, 1/05 CSMIP)
CSMIP PRELIMINARY PROCESSING            (ORIGIN:  TO BE DETERMINED)
36529-E0565-04272.02                 START TIME:  9/28/04, 17:15:11.4 UTC (WWVB)
STATION NO. 36529   35.878N, 120.358W     SSA-1  S/N  565  (3 CHNS OF  6 AT STA)
PARKFIELD - TURKEY FLAT #1 (0 & 24M)      CGS
CHAN  1: 270 DEG                    LOCATION: SURFACE
RECORD OF SAT SEP 28, 2004 10:15:11.4 PDT    SAT SEP 28, 2004 10:15:11.4 PDT
HYPOCENTER:  TO BE DETERMINED.               ML:  TO BE DETERMINED.
INSTR PERIOD =  .0222 SEC,  DAMPING =  .700,  SENSITIVITY = 1.25  V/G  (NOMINAL)
                        RECORD LENGTH = 81.920 SEC.
                                     UNCOR MAX  =   .245 G , AT  18.075 SEC.
RMS ACCEL OF (UNCOR) RECORD  =        .   STA. METADATA EFFECTIVE DATE: 01/01/04
ACCELEROGRAM BANDPASS FILTERED WITH 3 DB PTS AT   .13 AND 20.00 CYC/SEC
FFT COMPUTED FROM WINDOW STARTING AT  6.741  SEC AND ENDING AT  14.741 SEC.
AMPLITUDE SPECTRA OF STATION AND REFERENCE SMOOTHED 2 TIMES
WITH A 1.074 HZ RUNNING MEAN FILTER BEFORE FORMING SPECTRAL RATIO.
SPECTRAL RATIO DATA BEGINS AT  .125 HZ AND ENDS AT 20.000  HZ.
77 POINTS OF SPECTRAL RATIO DATA AT UNEQUALLY-SPACED INTERVALS.
PARKFIELD EARTHQUAKE
STRONG-MOTION EVENT 12, TURKEY FLAT ARRAY, ROCK SOUTH (SURFACE) CHAN  1:  90 DEG
    1    1    1    3    3    0    1    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0   90 2873   40   40   25    0
    0    0    0    0    0    0    0    1    0    0    0    0    0    0    0    0
    0    0 2873 2873 2873    0    0    0    0    0   25   80    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
     0.500     0.600    28.720     0.000     0.000     0.000     0.000     0.000
     2.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000    12.566     0.000
     0.000     0.000     0.000     0.000     0.010     0.000     0.000     0.000
     7.840  -415.426     7.870     9.047    10.770    -0.353     0.007     0.000
     0.000     0.000    -0.002     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
     0.000     0.000     0.000     0.000
   77 UNEVENLY SPACED FREQUENCY POINTS WHERE SPECTRAL RATIO HAS BEEN DETERMINED:
     0.125     0.222     0.319     0.416     0.513     0.610     0.707     0.967
     1.270     1.660     1.855     1.953     2.246     2.637     2.832     2.930
            ...
            ... (Remainder of spectral ratio data) ...
            ...
      SPECTRAL RATIO CORRESPONDING TO ABOVE FREQUENCY POINTS IN UNITS OF RATIO:
     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000
     1.000     1.000     1.000     1.000     1.000     1.000      .000     1.000
            ... (Remainder of spectral ratio data) ...

/&    <——-  ...(End of data for this channel)...

            ... (Header, etc for next channel)
```

## Technical Report Series on the Turkey Flat, USA Site Effects Test Area

Turkey Flat, USA Site Effects Test Area – Report 1: Needs, Goals, and Objectives. TR 86-1, California Department of Conservation, Division of Mines and Geology.

Turkey Flat, USA Site Effects Test Area – Report 2: Site Characterization. TR 88-2, California Department of Conservation, Division of Mines and Geology.

Turkey Flat, USA Site Effects Test Area – Report 3: Weak-Motion Test: Prediction Criteria and Input Rock Motions. TR 89-1, California Department of Conservation, Division of Mines and Geology.

Turkey Flat, USA Site Effects Test Area – Report 4: Weak-Motion Test: Observed Seismic Response. TR 90-1, California Department of Conservation, Division of Mines and Geology.

Turkey Flat, USA Site Effects Test Area – Report 5: Weak Motion Test: Statistical Analysis of Submitted Predictions and comparisons to Observations. TR 90-2, California Department of Conservation, Division of Mines and Geology.

Turkey Flat, USA Site Effects Test Area – Report 6: Weak-Motion Test: Observations and Modeling. TR 91-1, California Department of Conservation, Division of Mines and Geology.

Turkey Flat, USA Site Effects Test Area – Report 7: Strong-Motion Test: Prediction Criteria and Data Formats. CSMIP OSMS 05-1, Department of Conservation, California Geological Survey.